Completed Project (2011 - 2014)

Atmosphere Resource Recovery & Environmental Monitoring (ARREM) for Long Duration Exploration Project

Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)

ABSTRACT

The AES Atmosphere Resource Recovery & Environmental Monitoring (ARREM) for Long Duration Exploration Project project is maturing Atmosphere Revitalization Systems (ARS) and Environmental Monitoring (EM) systems that will reduce risk, lower lifecycle cost, and validate operational process design and system architectural concepts for future human exploration missions. The project is maturing these technologies using the ISS state-of-the-art hardware as a point of departure.

This project merged into the AES Life Support Systems Project in FY15.

ANTICIPATED BENEFITS

To NASA funded missions:

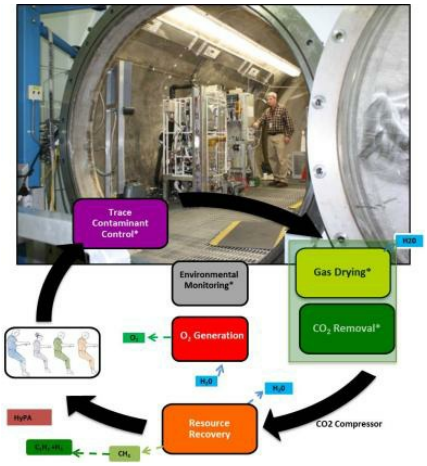
The project is advancing the technical maturity of candidate technologies for a flexible Atmosphere Revitalization Systems (ARS) and Environmental Monitoring (EM) systems architectures spanning the range of exploration mission objectives and vehicle concepts, thus providing risk reduction and developmental economy to flight project development programs.

Anticipated benefits include:

- Technologies could be used to help reduce CO_2 levels in the environment
- Monitoring of harmful chemical contamination in air and water
- Improved air purification systems in closed environments

To NASA unfunded & planned missions:

The project is developing a set of resource recovery capabilities and monitors that can be added in modular “plug-n-play” fashion to a common set of core, modular Atmosphere Revitalization Systems (ARS) and Environmental Monitoring (EM) systems



Atmosphere Resource Recovery & Environmental Monitoring (ARREM) for Long Duration Exploration Project

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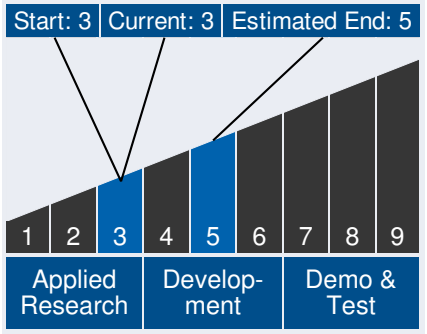
Technology Maturity



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equipment. This will enable mission planners to extend crewed mission durations without compromising core equipment functionality.

To other government agencies:

The maturation of life support technologies can also potentially benefit Navy submarines and homeland security technology needs.

To the commercial space industry:

The project advances technologies and knowledge that may be provided on a commercial basis. The maturation of life support technologies can also potentially benefit Navy submarines and homeland security technology needs.

To the nation:

The project supports the development of sustainable human long-term human space exploration. The project advances technologies and knowledge that may be provided on a commercial basis. The maturation of life support technologies can also potentially benefit Navy submarines and homeland security technology needs.

DETAILED DESCRIPTION

The project focuses on key physico-chemical process technologies for Atmosphere Revitalization Systems (ARS) that increase reliability, capability, and consumable mass recovery as well as reduce requirements for power, volume, heat rejection, and crew involvement. For the Environmental Monitoring (EM) systems effort, the project is developing and demonstrating onboard analysis capabilities that will replace the need to return air and water samples to earth for ground analysis. This effort is addressing these challenges by adopting a new architecture that is based on the modular integration of multiple sensing modalities, employing a hybrid combination of simple, rugged technologies and, where needed, highly capable

Management Team

Program Director:
- Jason Crusan

Program Executive:
- Barry Epstein

Project Managers:
- David Howard
- Monserrate Roman

Technology Areas

Primary Technology Area:
Human Health, Life Support, and Habitation Systems (TA 6)
- Environmental Control and Life Support Systems and Habitation Systems (TA 6.1)
  - Air Revitalization (TA 6.1.1)
    - Temperature and Humidity Control (TA 6.1.1.5)

Secondary Technology Area:
Human Health, Life Support, and Habitation Systems (TA 6)
- Environmental Control and Life Support Systems and Habitation Systems (TA 6.1)
  - Air Revitalization (TA 6.1.1)
    - Particulate and Microbial Control (TA 6.1.1.4)

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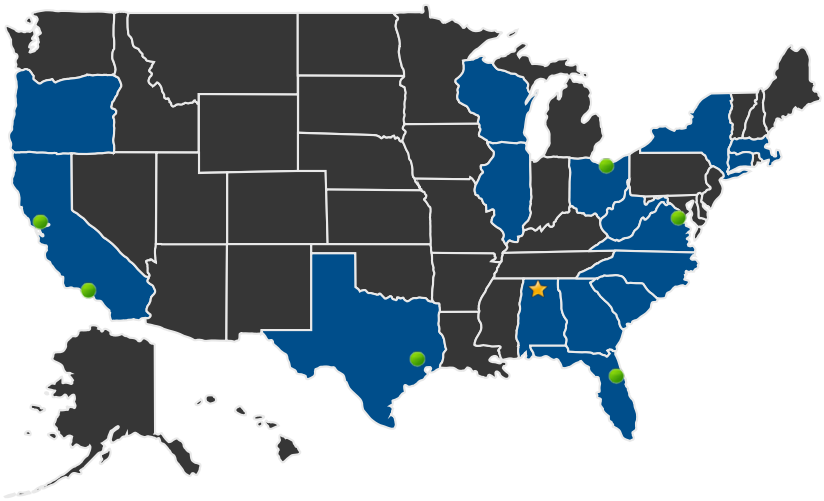
complex approaches, to completely address monitoring needs of the future. It incorporates Microelectromechanical Systems (MEMS) technologies to enable significant miniaturization over current systems, and selects elements offering both low resources and high reliability operation for affordability. The project is developing, demonstrating and/or testing leading process technology candidates and system architectures that will meet or exceed current requirements and fill capability gaps or significantly improve the efficiency, safety, and reliability over the state-of-the-art (SOA). The project's main goal is to demonstrate test articles (at various technology readiness levels) in a ground test facility under relevant flight conditions.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Marshall Space Flight Center

Technology Areas *(cont.)*

Additional Technology Areas:

Human Health, Life Support, and Habitation Systems (TA 6)
- Environmental Control and Life Support Systems and Habitation Systems (TA 6.1)
  - Air Revitalization (TA 6.1.1)
    - CO2 Removal (Closed Loop) (TA 6.1.1.1)
    - CO2 Reduction (TA 6.1.1.2)
    - Trace Contaminant Control (TA 6.1.1.3)

Human Exploration Destination Systems (TA 7)

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Supporting Centers:

- Ames Research Center
- Glenn Research Center
- Jet Propulsion Laboratory
- Johnson Space Center
- Kennedy Space Center
- Marshall Space Flight Center
- NASA Headquarters

Other Organizations Performing Work:

- Aerfil, LLC
- Al Razaq Computing Services
- Cbana Laboratories (Champaign, IL)
- CFD Research Corporation (Huntsville, AL)
- Dr. James Ritter
- Dynamac Corp.
- ECLS Technologies
- Georgia Tech
- Giner, Inc. (Newton, MA)
- Honeywell
- Jacobs Engineering Group
- Jacobs ESSA (Engineering Center Support Contract)
- JSC Engineering, Technical, and Science (JETS)
- Millennium Engineering and Integration
- MTS MIPSS (Engineering Center Support Contract)
- Orbital Technologies Corporation (Madison, WI)
- Port City Instruments, LLC
- Precision Combustion, Inc. (North Haven, CT)
- QinetiQ North America/ESC
- Teledyne Brown Engineering
- Thorleaf Research, Inc. (Santa Barbara, CA)
- UMPQUA Research Company (Myrtle Creek, OR)
- University of California, Berkeley
- University of California, San Diego (La Jolla, CA)
- University of Puerto Rico
- University of Southern California
- Wyle Laboratories

Contributing Partners:

- National Energy Technology Laboratory (NETL)
- U.S. Navy

DETAILS FOR TECHNOLOGY 1

Technology Title

Atmosphere Resource Recovery & Environmental Monitoring (ARREM) for Long Duration Exploration Project

Technology Description

This technology is categorized as a hardware system for manned spaceflight

The project focuses on key physico-chemical process technologies for Atmosphere Revitalization Systems (ARS) that increase reliability, capability, and consumable mass recovery as well as reduce requirements for power, volume, heat rejection, and crew involvement. For the Environmental Monitoring (EM) systems effort, the project is developing and demonstrating onboard analysis capabilities which will replace the need to return air and water samples to earth for ground analysis. This effort is addressing these challenges by adopting a new architecture that is based on the modular integration of multiple sensing modalities, employing a hybrid combination of simple, rugged technologies and, where needed, highly capable complex approaches, to completely address monitoring needs of the future. It incorporates MEMS technologies to enable significant miniaturization over current systems, and selects elements offering both low resources and high reliability operation for affordability. The project is developing, demonstrating and/or testing leading process technology candidates and system architectures that will meet or exceed current requirements and fill capability gaps or significantly improve the efficiency, safety, and reliability over the state-of-the-art (SOA). The project's main goal is to demonstrate test articles (at various technology readiness levels) in a ground test facility under relevant flight conditions.

Capabilities Provided

The project is demonstrating the evolution of the International Space Station (ISS) state-of-the-art (SOA) Atmosphere Revitalization Systems (ARS) and Environmental Monitoring (EM) systems baseline via targeted advancements that benefit ISS operations in low Earth orbit (LEO) and exploration missions beyond Earth orbit. Benefits include improved operational margins and reliability, reduced technical risk, and lower lifecycle cost.

Potential Applications

The project is advancing the technical maturity of candidate technologies for a flexible Atmosphere Revitalization Systems (ARS) and Environmental Monitoring (EM) systems architectures spanning the range of exploration mission objectives and vehicle concepts, thus providing risk reduction and developmental economy to flight project development programs. The technology advancement

under ARREM is needed for the ISS to reduce the resupply of spare parts from Earth and relieve maintenance burdens on the crew so they have more time available to conduct science experiments. For long-duration exploration missions beyond low Earth orbit, the ARREM project is vital to assure systems can integrate into future crew habitats and operate reliably when distances from Earth prevent quick return or intervention from the ground. Such missions will require critical life support systems to recover more resources from metabolic byproducts and maintain reliable operation when the option for mission abort and timely return to Earth is not possible.

Specific technologies include: the Plasma Pyrolysis Assembly (PPA), which can be integrated into existing state-of-the-art systems to improve the percentage of oxygen recovered from carbon dioxide from 43% to over 75%; advanced carbon dioxide removal sorbents that improve reliability by minimizing dust generation; Oxygen Generation Systems with fewer components, to decrease mass and complexity; improved air-born Trace Contaminant Control systems that reduce ancillary components and protects water condensate from undue chemical contamination; and a suite of miniaturized environmental monitoring sensors that considerably improve the capability to monitor both air and water quality to assure crew are exposed to only clean air and water conditions. These technologies are the basis for requirements to meet the next generation exploration missions and enable humans to explore new destinations beyond the reach of Earth's influence.